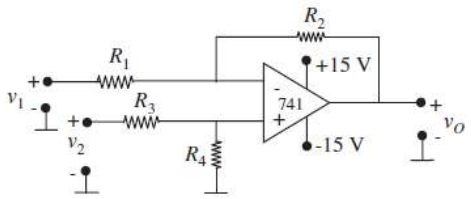
# Homework 4

Thursday, April 27, 2017 1:25 PM

Ex 15.4)




a. $V_+ = \frac{R_4}{R_3+R_4} V_2$ voltage divider

$\frac{V_1 - V_-}{R_1} + \frac{V_o - V_-}{R_2} = 0$

$V_o = V_- - \frac{R_2}{R_1}(V_1 - V_-)$ ideal op-amp $V_- = V_+$

$= \left(1 + \frac{R_2}{R_1}\right)\frac{R_4}{R_3+R_4} V_2 - \frac{R_2}{R_1} V_1$

$= \boxed{\frac{R_4(R_1+R_2)}{R_1(R_3+R_4)} V_2 - \frac{R_2}{R_1} V_1}$

b. connecting a load resistor from $V_o$ to ground does not change $V_o$ since $R_L$ would not show up in Kirchhoff current equations

c. $V_1 = V_2$, $R_1 = 1K\Omega$, $R_2 = 30K\Omega$, $R_3 = 1.5K\Omega$

$V_o = 0 \longrightarrow R_4(R_1+R_2) = R_2(R_3+R_4)$

$\boxed{R_4 = \frac{R_2 R_3}{R_1} = 45K\Omega}$

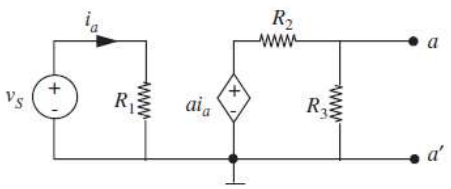
d. $V_2 = 0$, $V_1 = 1V$ use previous resistor values

$V_o = -\frac{R_2}{R_1} V_1$

$= -30V \longrightarrow$ power supply limits to $\pm 15V$

$\boxed{V_o = -15V}$

Ex 15.14)




$i_a = \frac{V_S}{R_1}$

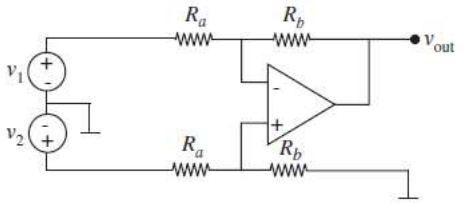
$V' = a i_a = \frac{a V_S}{R_1}$

$\boxed{V_{TH} = \frac{R_3}{R_2+R_3} V' = \frac{a R_3}{R_1(R_2+R_3)} V_S}$

$i_{SC} = \frac{V'}{R_2}$ (short output terminals)

$\boxed{R_{TH} = \frac{V_{TH}}{i_{SC}} = \frac{R_2 R_3}{R_2+R_3}}$

Ex 15.16)




$$V_+ = V_2 \frac{R_b}{R_a + R_b} = V_-$$

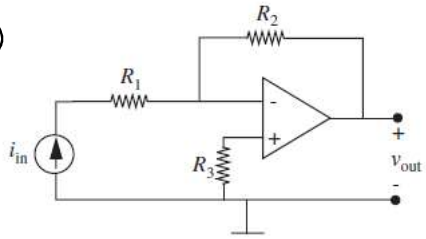
$$i_1 = \frac{V_1 - V_-}{R_a} = \frac{V_- - V_{out}}{R_b}$$

$$V_{out} = V_-\left(1 + \frac{R_b}{R_a}\right) - \frac{R_b}{R_a} V_1$$

$$= V_2 \frac{R_b}{R_a + R_b}\left(\frac{R_a + R_b}{R_a}\right) - \frac{R_b}{R_a} V_1$$

$$\boxed{V_{out} = \frac{R_b}{R_a}(V_2 - V_1)}$$

Ex 15.22)

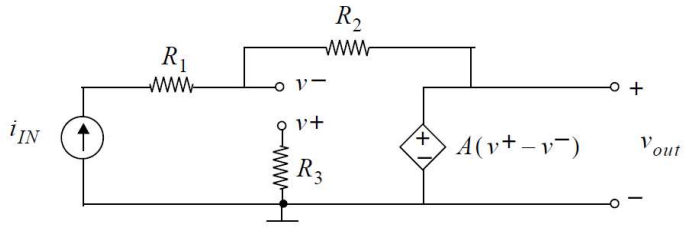



a. Ideal Op-Amp

$$V_+ = 0 = V_1$$

$$\boxed{V_{out} = -i_{in} R_2}$$

b.



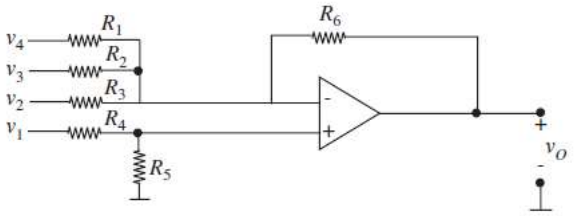

c. $V^+ = 0$

$$A(V^+ - V^-) - V^- = -i_{in} R_2$$

$$(A+1) V^- = i_{in} R_2 \longrightarrow V^- = \frac{i_{in} R_2}{1+A}$$

$$\boxed{V_{out} = -AV^- = -\frac{A i_{in} R_2}{1+A}}$$

Pr 15.8)




choose R s.t. $v_o = 2v_1 - 5v_2 - v_3 - 3v_4$

$$\frac{v_- - v_o}{R_6} = \frac{v_4 - v_-}{R_1} + \frac{v_3 - v_-}{R_2} + \frac{v_2 - v_-}{R_3}$$

$$v_- = v_+ = \frac{R_5}{R_4 + R_5} v_1$$

$$v_o = v_-\left(1 + \frac{R_6}{R_1} + \frac{R_6}{R_2} + \frac{R_6}{R_3}\right) - \frac{R_6}{R_1} v_4 - \frac{R_6}{R_2} v_3 - \frac{R_6}{R_3} v_2$$

$$= \frac{R_5}{R_4 + R_5}\left(1 + \frac{R_6}{R_1} + \frac{R_6}{R_2} + \frac{R_6}{R_3}\right) v_1 - \frac{R_6}{R_3} v_2 - \frac{R_6}{R_2} v_3 - \frac{R_6}{R_1} v_4$$

$$\frac{R_6}{R_3} = 5, \quad \frac{R_6}{R_2} = 1, \quad \frac{R_6}{R_1} = 3$$

$$\frac{R_5}{R_4 + R_5} = \frac{2}{10} = \frac{1}{5}$$